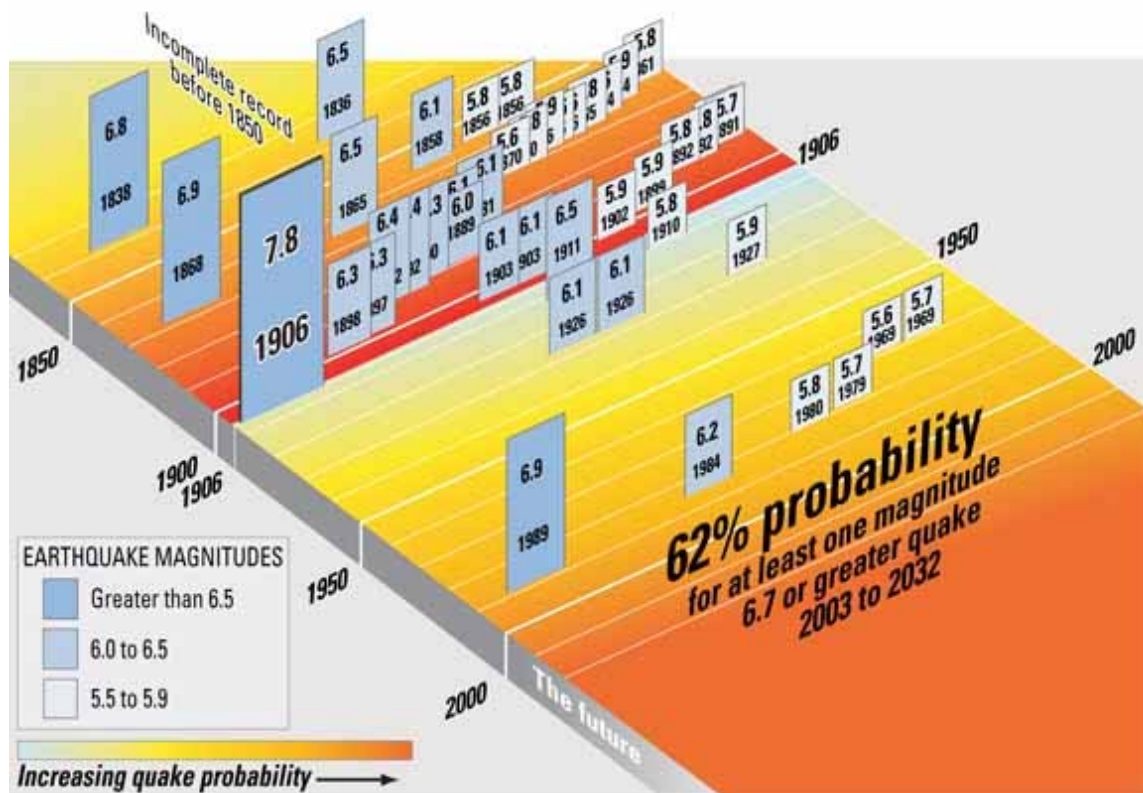


1. INTRODUCTION

Thousands of earthquakes occur every year around the San Francisco Bay Area. While most of the earthquakes go unnoticed, the Bay Area is highly susceptible to an earthquake of damaging magnitude on any number of local area faults. The U.S. Geological Survey (USGS) estimates that there is a 62 percent chance that a moment magnitude (M) 6.7 or larger earthquake will occur in the region before 2032 as illustrated in Figure A-1. This annex provides reference material for the San Andreas fault and describes the means for characterizing earthquakes and the risks associated with earthquakes in the Bay Area.

**Figure A-1
Earthquake Probability**



Source: Putting Down Roots in Earthquake Country, USGS, 2005

1.1. Nature

An earthquake is due to movement, generally sudden, along a geologic fault, which results in a release of strain accumulated within or along the edge of the earth's tectonic plates. The effects of an earthquake can be felt far beyond the site of its occurrence. Earthquakes usually occur without warning and, after just a few seconds, can cause massive damage and extensive casualties. The most common effect of earthquakes is ground motion – that is, the vibration or shaking of the ground during an earthquake.

Ground shaking is caused by waves in the earth's interior, also known as seismic waves, and along the earth's surface, known as surface waves.

The severity of an earthquake can be expressed in terms of intensity. Intensity is based on the damage and observed effects on people and the natural and built environment. It varies from place to place depending on the size and rupture characteristics of the earthquake, the distance from the event, the properties of the earth in which the seismic waves travel and the local geographic conditions. Intensity generally increases with the amount of energy released and decreases with distance from the causative fault of the earthquake. The scale most often used in the United States to measure intensity is the Modified Mercalli Intensity (MMI) scale. As shown in Table A-1, the MMI scale consists of 12 increasing levels of intensity that range from imperceptible to catastrophic destruction. Peak ground acceleration (PGA) is used as a measure of earthquake ground shaking. PGA is often expressed in terms of the acceleration due to gravity, or g.

Magnitude is a measure of an earthquake's strength. It is related to the amount of seismic energy released by the earthquake's causative fault. Magnitude is based on the amplitude of the earthquake waves recorded on instruments.

Table A-1 shows the characteristic differences between magnitude, intensity, and PGA and provides context for these concepts in terms of the shaking felt.

Table A-1
Magnitude / Intensity / Ground Shaking Comparisons

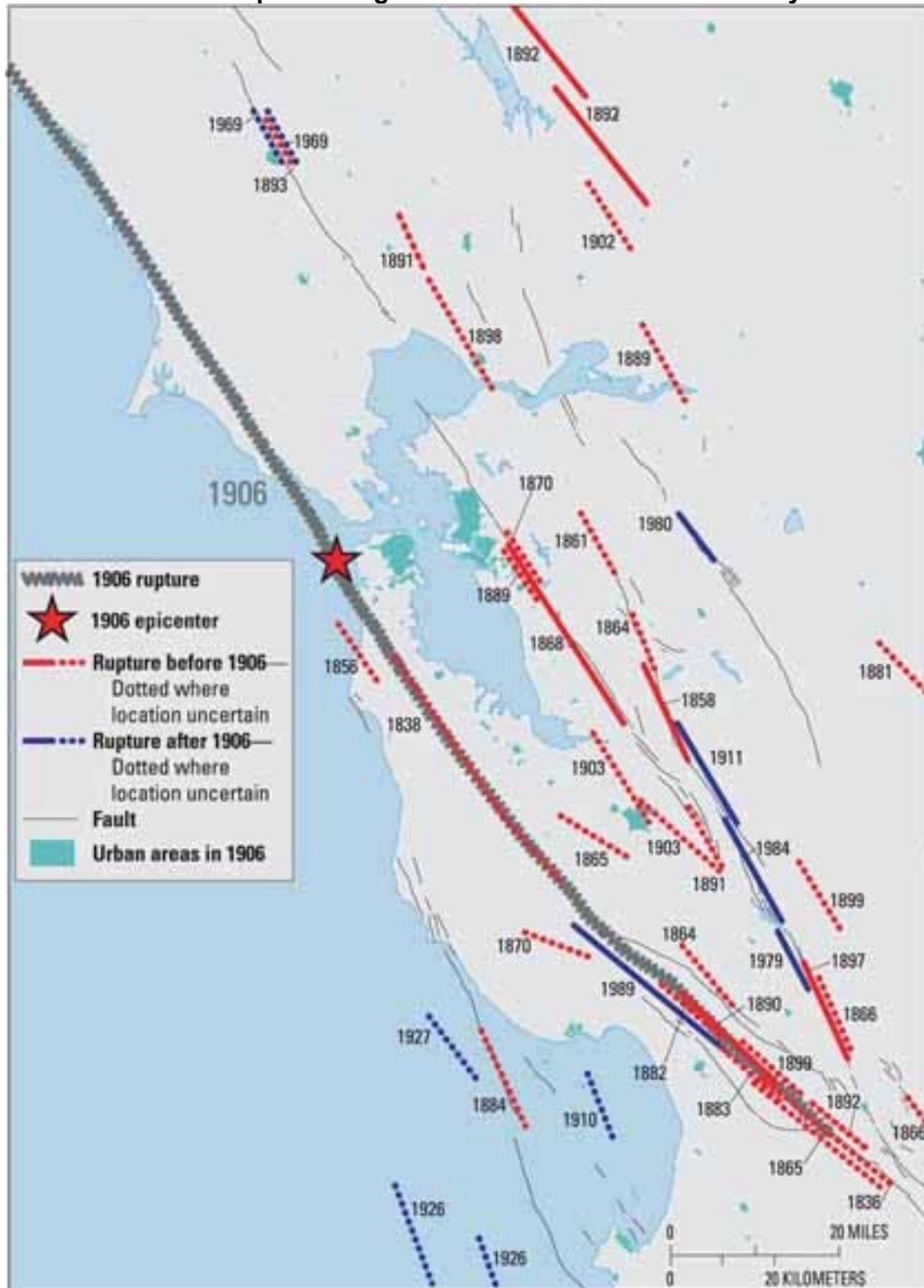
Magnitude	Intensity	PGA (% g)	Perceived Shaking
1.0 – 3.0	I	<0.17	Not Felt
3.0 – 3.9	II-III	0.17 – 1.4	Weak
4.0 – 4.9	IV	1.4– 3.9	Light
	V	3.9 – 9.2	Moderate
5.0 – 5.9	VI	9.2 – 18	Strong
	VII	18 – 34	Very Strong
6.0 – 6.9	VIII	34 – 65	Severe
	IX	65 – 124	Violent
	X	124 +	Extreme
7.0 +	XI		
	XII		

Source: USGS 2006

1.2. History

The San Andreas Fault system has a record of moderate to great earthquakes in recent, recorded history. In the period from 1800 to the present, 21 earthquakes of M 6.0 or greater have been documented in the region as illustrated in Figure A-2.

Figure A-2
Fault Rupture Lengths for Historic Quakes in the Bay Area



Source: Putting Down Roots in Earthquake Country, USGS, 2005

One of the region's earliest known great earthquake events occurred in June 1838 along the Peninsula segment of the San Andreas Fault. It is believed that this event was a M 7.0 to 7.4. The region's next largest earthquake occurred on October 21, 1868. This M 7.0 earthquake occurred along the southern segment of the Hayward Fault.

The region's most well-known earthquake, produced by the San Andreas Fault, occurred on April 18, 1906. Known as the "Great San Francisco Earthquake," this event lasted 45 to 60 seconds and was an estimated M 7.7 to 7.9. It is believed that the epicenter may have been just west of Daly City and that the length of the fault rupture was approximately 300 miles. MMI of VIII (moderate damage) to IX (heavy damage) extended as much as 60 miles inland. The greatest amount of damage occurred in the region's existing urban areas. In San Francisco, it is estimated that the earthquake and post-earthquake fires killed approximately 700 to 800 people (although recent research suggests this number is more likely around 3,000 people) and destroyed nearly 28,000 buildings.

On October 17, 1989, the Loma Prieta earthquake occurred near Mount Loma Prieta in Santa Cruz County. The earthquake lasted only 10 to 15 seconds but was a M 6.9 to 7.1. MMI of X (extreme damage) to IX (heavy damage) was limited to an area adjacent to the San Andreas Fault in the southern Santa Cruz Mountains. However, some of the heaviest damage occurred some 60 miles north in San Francisco's Marina District and in the East Bay. In these areas, poor soil conditions due to 19th century non-engineered fill amplified ground motions and produced liquefaction. A total of 62 deaths and 400 severe injuries were reported. In addition, over 12,000 homes and 2,600 businesses were damaged or destroyed. Additionally, major transportation facilities, including the eastern span of the Bay Bridge, the Cypress Freeway in Oakland, and the Embarcadero Freeway in San Francisco were severely damaged.

1.3. Location, Extent, and Probability of Future Events

The Bay Area is exposed to seismic hazards from numerous known faults and potentially tons of unmapped or undiscovered faults. Most of the major faults in the Bay Area are strike-slip faults, where the rupture plane is oriented vertically and the ground on one side of the fault slips horizontally past the ground on the other side of the fault. There are, however, several thrust or reverse faults in the Bay Area, where ground on one side of the fault moves upward and over the opposing side of the fault. As noted earlier, the most active strike-slip fault in the region is the San Andreas Fault, which has 10 major known fault segments. Although the San Andreas Fault does not run directly through the City of San Francisco, the fault trends through the area, 20 miles south of San Francisco. That is, the fault is located to the west of San Francisco in the Pacific Ocean until it heads inland just south of the city limits. Table A-2 lists the major known faults located within the Bay Area region.

Table A-2
Major Known Faults in the San Francisco Bay Area Region

Name	Location	Length	Most Recent Significant M > 6.5 Earthquakes
San Andreas Fault	Gulf of California to Mendocino	1,000 km	1906
Concord Fault	Contra Costa, Solano Counties	18 km	Holocene
Calaveras Fault	Alameda, Contra Costa Counties	45 km	1160 - 1425
Hayward Fault	Alameda, Contra Costa, Marin Counties	42 km	1868
San Gregorio Fault	Marin, Monterey, San Mateo, Santa Cruz Counties	130 km	1270 - 1776
Rodgers Creek Fault	Sonoma County	56 km	1640 - 1776
Greenville Fault	Contra Costa, Alameda, San Clara Counties	147 km	Holocene
Mt. Diablo Thrust Fault	Contra Costa County	8 km	Late Quaternary

Source: USGS 2005

In 2002, the USGS determined with a 62 percent probability that a M 6.7 or greater earthquake will strike the region by 2031 as illustrated in Figure A-3.

Figure A-3
San Francisco Bay Region Earthquake Probability



Source: Putting Down Roots in Earthquake Country, USGS, 2005

Table A-3 shows the 10 most likely damaging earthquake scenarios in the region over a 30-year period.

Table A-3
Ten Most Likely Damaging Earthquake Scenarios

Fault	30-Year Probability (Percent)	Mean Magnitude (M)
Rodgers Creek Fault	15.2	7.0
Northern Calaveras Fault	12.4	6.8
Southern Hayward Fault	11.3	6.7
Northern and Southern Hayward Fault	8.5	6.9
Mt. Diablo Thrust	7.5	6.7
Green Valley – Concord Fault	6.0	6.7
San Andreas Fault, North Coast segment	4.7	7.9
San Andreas Fault, Peninsula segment	4.4	7.2
San Gregorio Fault, Northern segment	3.9	7.2
San Andreas Fault, Peninsula and Santa Cruz segment	3.5	7.4

Source: USGS 2003

1.4. Effects – Shaking

Damage in an earthquake is primarily from shaking. The intensity of shaking a structure will experience during an earthquake is a function of three factors:

- **Magnitude** - the measure of the earthquake strength. Therefore, the bigger the earthquake, the more energy is released and the more intense shaking is felt.
- **Distance** - earthquake waves diminish in intensity as they travel through the ground, so earthquake shaking is generally less intense farther from the fault.
- **Location** - soil conditions can also affect shaking. Shaking can become amplified in areas of soft soils and fill.

A significant tool available to estimate the potential range of impacts of an earthquake is "ShakeMap", developed by the USGS. ShakeMap uses the sensor information from the Advanced National Seismic System to map actual ground shaking intensity in near real-time after an event. The program is capable of producing a color-coded map of the shaking intensity produced over a region and posting the map to the Internet within 60 minutes of an earthquake. The color-coding of the map is based on the MMI Scale. Table A-4 shows the color-coding used to identify shaking intensity on shake maps.

Table A-4
Modified Mercalli Shaking Intensity Scale

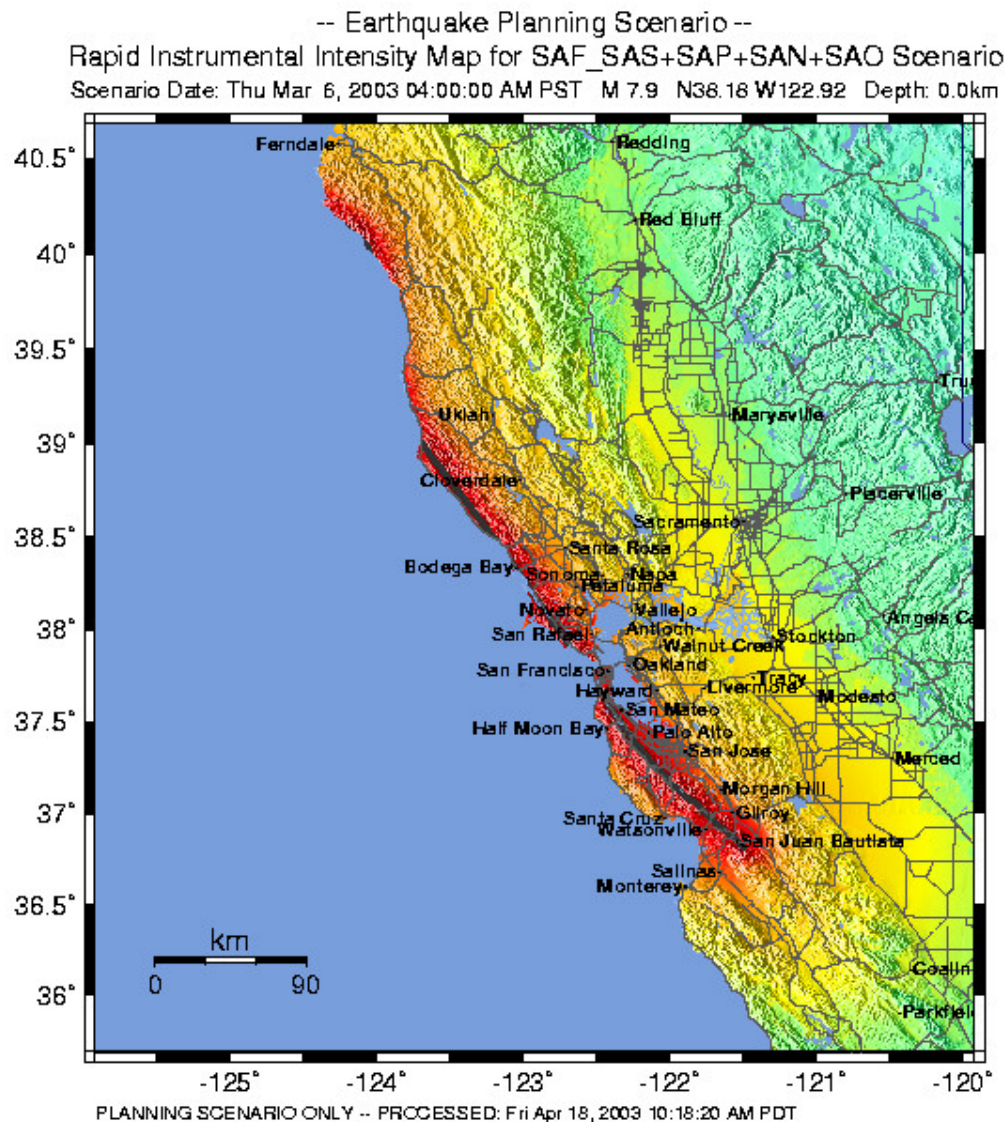
Shake Map Color	Intensity (MMI) Value	Perceived Shaking	Potential Damage	Full Impact Description
White	I	Not Felt	None	NONE.
Light Blue/Aqua	II	Weak	None	Felt by people at rest on upper floors.
Aqua/Light Green	III	Weak	None	Felt indoors, hanging objects sway, vibration like passing truck.
Light Blue/Green	IV	Light	None	Hanging objects sway, vibration like a heavy truck passing.
Green/Yellow	V	Moderate	Very Light	Felt outdoors, sleepers wakened, liquids spill, small, unstable objects displaced or upset.
Yellow/ Light Orange	VI	Strong	Light	Felt by all, many frightened, run outdoors. Windows break, dishes & books fall off shelves, pictures fall
Light Orange/Dark Orange	VII	Very Strong	Moderate	Difficult to stand, drivers' notice, furniture moved, cracks in masonry, weak chimneys break.
Dark Orange/ Light Red	VIII	Severe	Moderately Heavy	Difficulty steering cars, damage to masonry, partial collapse of stucco and some masonry walls. Chimneys fall. Frame structures move relative to foundation.
Light Red/ Medium Red	IX	Violent	Heavy	General panic, older masonry buildings destroyed or heavily damaged. Frame structures shift off foundation if not bolted. Underground pipes broken.
Medium Red/Deep Red	X	Extreme	Very Heavy	Most masonry and frame structures destroyed with their foundations. Some well-built wood frame structures destroyed. Serious damage to dams, dikes. Large landslides.
Deep Red	XI	Extreme	Very Heavy	Rails bent greatly, underground pipelines completely out of service.
Deep Red	XII	Extreme	Very Heavy	Damage nearly total.

Source: USGS, 2006

1.5. ShakeMaps

ShakeMaps have been created for the segments of the San Francisco Bay Area that repeats the 1906 San Andreas earthquake. Figure A-4 identifies a ShakeMap for the region.

Figure A-4
ShakeMap – San Andreas Fault – Repeat of 1906

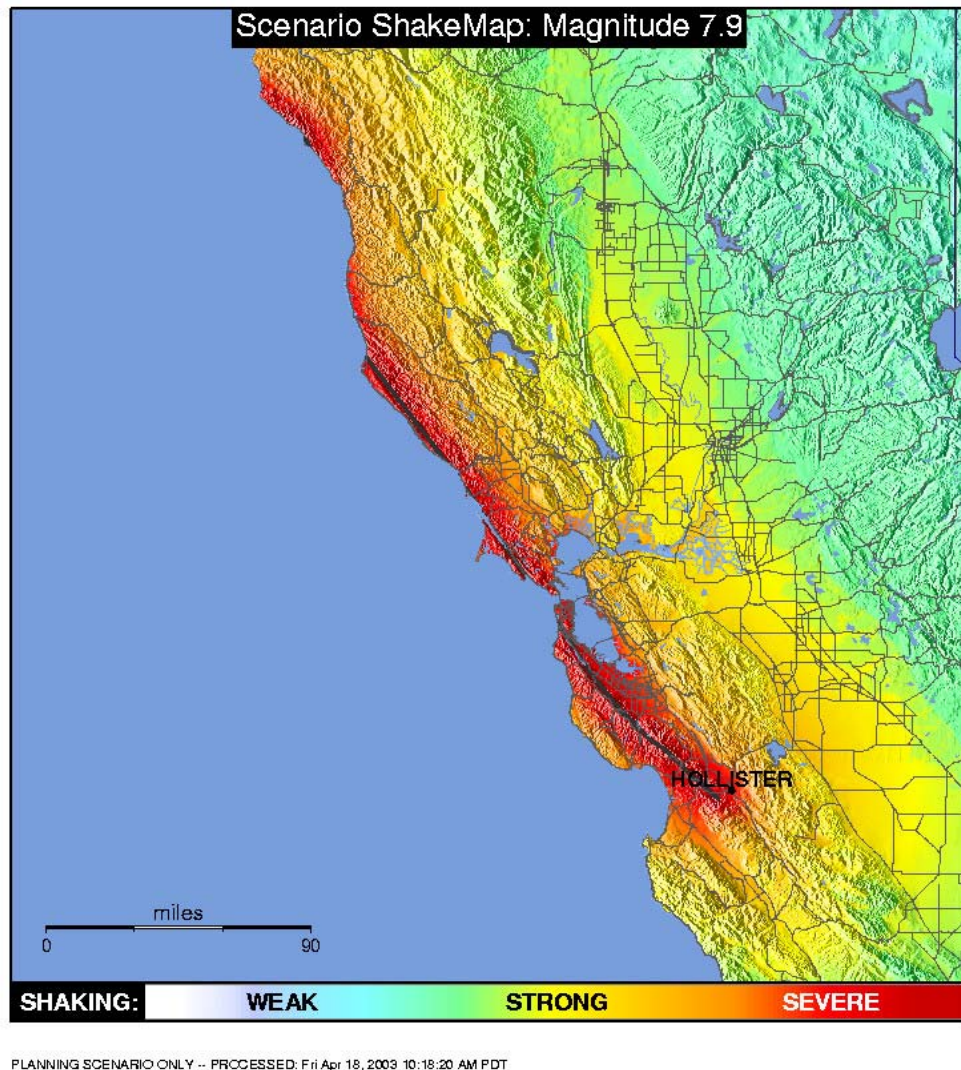


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC. (m/s ²)	< .17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL. (cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Source: USGS, 2006

USGS also produces a map for the media. Figure A-5 is an example of a map showing a repeat of the 1906 San Andreas Earthquake scenario.

Figure A-5
Media Map – San Andreas Fault – Repeat of 1906



Source: USGS, 2006

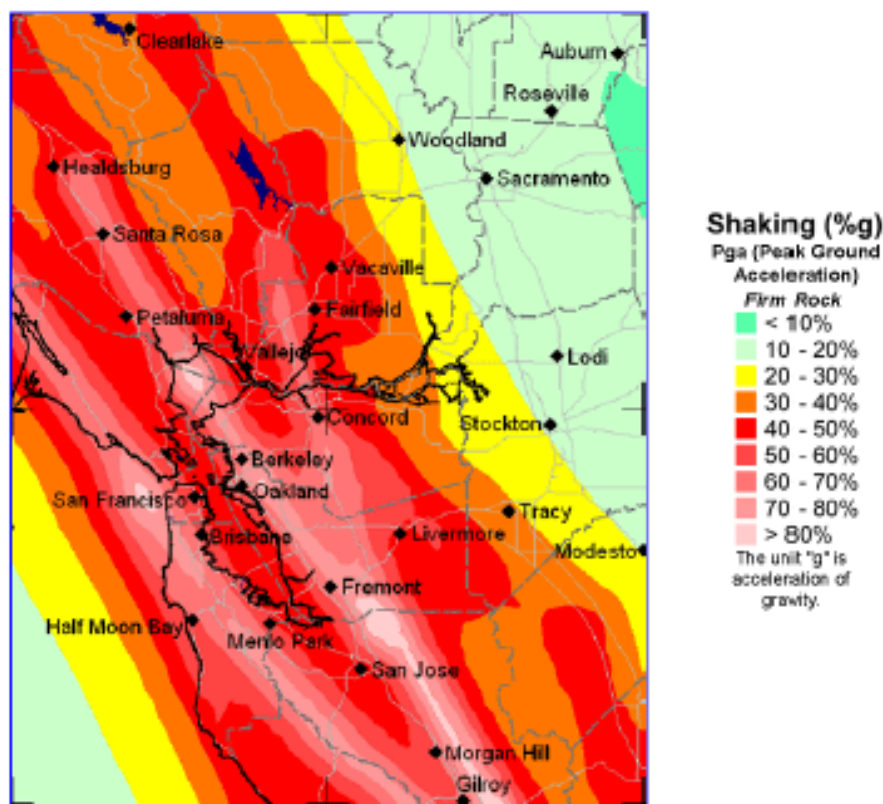
1.6. Probabilistic Seismic Hazard Map

A probabilistic seismic hazard map is a map that shows the hazard from earthquakes that geologists and seismologists agree could occur in California. It is probabilistic in the sense that the analysis takes into consideration the uncertainties in the size and location

of earthquakes and the resulting ground motions that can affect a particular site. The maps are typically expressed in terms of probability of exceeding a certain ground motion. For example, the 10% probability of exceedance in 50 years maps depicts an annual probability of 1 in 475 of being exceeded each year. This level of ground shaking has been used for designing buildings in high seismic areas.

Figure A-6 identifies the bands of highest expected shaking following major earthquake faults.

Figure A-6
Probabilistic Seismic Hazard Map

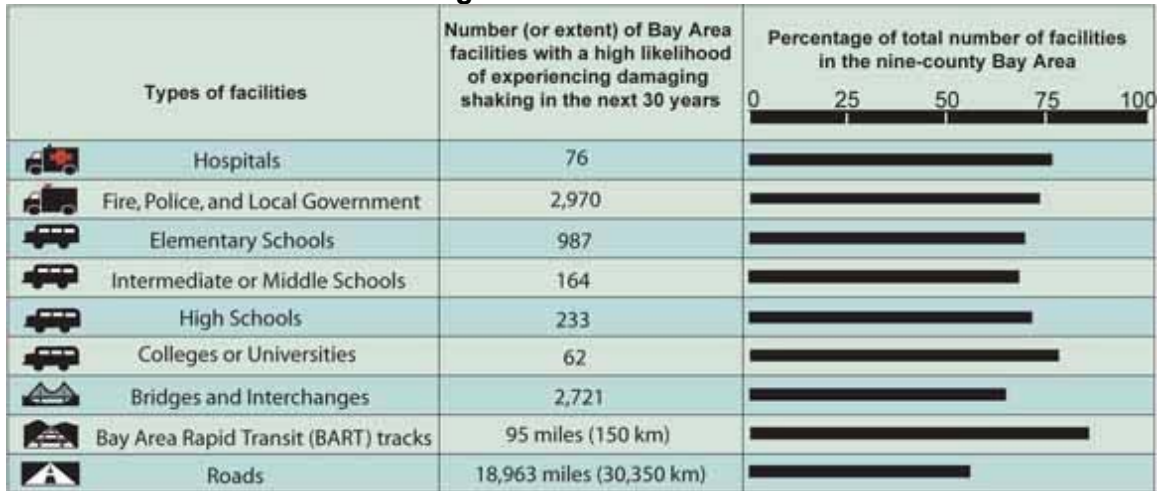


Source: www.seismic.ca.gov/pub/intensitymaps/sfbay_county_print.pdf

1.7. Shaking - Critical Structures

Many critical structures will likely experience damaging earthquake shaking over the next thirty years in the San Francisco Bay Area. Figure A-7 illustrates the likelihood of damage to these facilities

Figure A-7
Damage to Critical Structures



Source: Putting Down Roots in Earthquake Country, USGS, 2005

Specifically the following structures (Table A-5) have been identified as particularly susceptible to damage during a San Andreas earthquake.

Table A-5
Damage to Critical Structures – San Andreas Earthquake

Entity	Street Address	Coordinates	Probability
TRANSIT SYSTEMS			
VTA (Santa Clara Valley Transportation Authority)			
Headquarters – River Oaks	3331 North First Street, San Jose, CA 95134-1906	N37 24.115 W121 56.374	Low
Guadalupe Light Rail Facility & EOC	101 West Younger Avenue San Jose, CA 95110	N37 21.277 W121 54.361	High
Cerone Bus Facility	3990 Zanker Road San Jose, CA 95134	N37 25.147 W121 56.339	Low
Chaboya Bus Facility	2240 South 7 th Street San Jose, CA 95112	N37 18.357 W121 51.40	Medium
North Yard Bus Facility	1325 La Avenida Street Mountain View, CA 94040	N37 24.804 W122 04.575	Low
Track section	After an earthquake, VTA would stop all the services and would run them at very reduced speeds. Most of stations are retrofitted with half inch tolerance that would keep the track away from the track.		NA
Caltrain			
Headquarters	1250 San Carlos Ave., PO Box 3006, San Carlos, CA 94070-1306	N37 30.372 W122 15.704	High
Dispatch – EOC – Operations Center	510 West San Fernando San Jose, CA 95110	N37 19.752 W121 54.018	Medium
New Maintenance Center	West Taylor and Stockton San Jose, CA	N37° 20'26.30" W121° 54'48.35"	Low
Diridon Station	65 Cahill Street	N37° 46'34.46"	High

Metropolitan Transportation Commission
San Francisco Bay Area Regional Transportation Emergency Management Plan

Entity	Street Address	Coordinates	Probability
	San Jose, CA	W122° 23'38.04"	
Santa Clara Station		N37° 19'48.85" W121° 54'07.87"	High
San Francisco Station	4 th and King San Francisco, CA	N37° 21'17.16" W121° 56'14.52"	Low
Bridges and Overpasses	Various locations - There are 27 bridges and approximately 15 highways over crossings that could be expected to fail.		NA
SamTrans			
Headquarters - EOC	1250 San Carlos Ave., PO Box 3006, San Carlos, CA 94070-1306	N37 30.372 W122 15.704	High
Bus Facility	301 North Access Road San Francisco, CA	N37 38' 13.37 W122 23' 15.52	High
Bus Facility	501 Picko San Carlos, CA	N37 30' 56.85 W122 15' 02.94	High
Bus Facility	934 Brewster Redwood City, CA	N37 29' 24.11 W122 13' 58.60	High
Trains	Trains run all the way from San Francisco to Gilroy. They would be shut down until the investigation of the tracks and the weak links would be the underpasses and overpasses which are more likely to fail.		NA
Transbay Terminal	427 Mission Street San Francisco, CA	N37 47.417 W122 23.809 Or N37 47.380 W122 23.786	Low
San Francisco Municipal Railway (Muni)			
Main Offices	1 S. Van Ness Avenue, San Francisco, CA	N37 46.750 W122 25.206	High
Cable Car Division	Cable Car Museum 1201 Mason Street San Francisco, CA 94108	N37 47.672 W122 24.685	High
Maintenance Facility	700 Pennsylvania Avenue San Francisco, CA	N37 45.442 W122 23.587	High
Power Control Facility	2502 Alameda Street San Francisco, CA	N37 46.095 W122 24.583	High
Flynn Division (articulated buses)	1940 Harrison Street San Francisco, CA	N37 45.927 W122 24.787	High
Potrero and Street Operations	2500 Mariposa Street San Francisco, CA	N37 45.790 W122 24.479	Medium
Woods Division	1001 22 nd Street San Francisco, CA	N37 45.466 W122 23.471	Medium
Woods Maintenance	1095 Indiana San Francisco, CA	N37 45.374 W122 23.461	Medium
Green Division (light rail facility)	425 Geneva Avenue San Francisco, CA	N37 43.269 W122 26.849	Medium
Geneva Division	2310 San Jose Avenue San Francisco, CA	N37 43.244 W122 26.796	Medium
Presidio Division	2600 Geary San Francisco, CA	N37 46.955 W122 26.751	Medium
Presidio Offices	949 Presidio San Francisco, CA	N37 46.986 W122 26.757	Medium
Kirkland Division	2310 Stockton San Francisco, CA	N37 48.429 W122 24.630	Medium
Operations Central Control - EOC	131 Lennox Way San Francisco, CA	N37 44.512 W122 27.927	Medium

Metropolitan Transportation Commission
San Francisco Bay Area Regional Transportation Emergency Management Plan

Entity	Street Address	Coordinates	Probability
Mint Yard (rail storage yard – streetcar)	1 Buchanan San Francisco, CA	N37 46.190 W122 25.616	Medium
Scott Division (non-revenue vehicles)	1849 Harrison San Francisco	N37 46.080 W122 24.861	Medium
Marin Division (bus storage and track storage)	1395 Marin San Francisco, CA	N37 44.929 W122 23.419	Medium
MTA Security Division	875 Stevenson, Suite 204 San Francisco, CA	N37° 46'34.02" W122°25'00.21"	Medium
Power Control Substation	505 Illinois Street San Francisco, CA	N37° 45'53.82" W122°23'16.26"	Medium
Power Control Substation	702 Phelps Street San Francisco, CA	N37° 44'27.92" W122°23'25.15"	Medium
Power Control Substation	3400 Keith Street San Francisco, CA	N37° 43'10.52" W122°23'54.12"	Medium
Track section	No comment on unavailable track section		NA
Golden Gate Transit District			
Headquarters – San Rafael Bus Yard	1011 Anderson Dr, San Rafael, CA, 94901	N37 57.345 W122 30.302	High
EOC	Toll Plaza Administration Building SF Side of Hwy 101 San Francisco, CA	N37 48.528 W122 28.621	Medium
Santa Rosa Bus Yard	3225 Industrial Way Santa Rosa, CA	N38 28.322 W122 44.408	Medium
Novato Bus Yard	801 Golden Gate Place Novato, CA	N38 06.828 W122 34.037	High
San Francisco Bus Yard	350 8 th Street San Francisco, CA	N37 46.463 W122 24.555	High
Metropolitan Transportation Commission (MTC) - EOC	MetroCenter 101 Eighth Street Oakland, CA 94607	N37 47.818 W122 15.930	Low
Bay Area Rapid Transit (BART)			
Headquarters of BART and the Capitol Corridor Joint Powers Authority	300 Lakeside Drive Oakland, CA	N37° 48'32.77" W122° 15'47.47"	Low
EOC	101 Eighth Street Oakland, CA 94607	N37 47.818 W122 15.930	Low
Hayward Yard and Shops (Maintenance)	Located at Hayward station 699 B Street Hayward, CA	N37° 40'14.49" W122° 05'14.25"	Medium
Daly City Yard	500 John Daly Boulevard Daly City, CA	N37° 42'18.99" W122° 28'10.12"	Medium
Richmond Yard	1700 Nevin Avenue Richmond, CA	N37° 56'12.14" W122° 21'09.47"	Low
Concord Yard	1451 Oakland Avenue Concord, CA	N37° 56'26.29" W122° 01'41.39"	Low
Administrative and Storage Buildings			NA
Aerial Structures (24)	Retrofits done but exact location not known		NA
Transbay Tube		N37° 48'03.41" W122° 22'36.99"	High Poor soils conditions may lead to shutdown
Berkeley Hills Tunnel	Between Rockridge and Orinda stations	N37° 51'17.28" W122° 12'59.76"	Low
Bored Tunnels, Cut and Cover Tunnels	Unable to identify exact locations		Low

Metropolitan Transportation Commission
San Francisco Bay Area Regional Transportation Emergency Management Plan

Entity	Street Address	Coordinates	Probability
Operating Systems, Equipment and Components	Unable to identify exact locations		Low-Medium
Caltrans – District 4 Headquarters – EOC	111 Grand Ave Oakland, CA 94612	N37 48.682 W122 15.907	Low
AC Transit			
Headquarters	1600 Franklin Street Oakland, CA	N37 48.328 W122 16.138	Low
Hayward Bus Facility	1758 Sabre Street Hayward, CA	N37 39.390 W122 07.913	Low
East Oakland Bus Facility	1100 Seminary Oakland, CA	N37 45.716 W122 12.246	Low
Emeryville Bus Facility - EOC	1177 47 th Street Emeryville, CA 94608	N37 50.124 W122 16.963	Low
Richmond Bus Facility	2016 McDonald Avenue Richmond, CA	N37 56.147 W122 21.028	Low
Central Maintenance Facility	10626 International Boulevard Oakland, CA	N37 44.319 W122 09.975	Low
Vallejo Transit Headquarters- Bus Facility and EOC	1850 Broadway Vallejo, CA 94589	N38 08.033 W122 15.141	Low
Livermore – Amador Valley Transit Authority – Wheels Headquarters – Bus Facility – EOC	1362 Rutan Court, Suite 100, Livermore, California 94551	N37 41.565 W121 48.025	Low
Central Contra Costa County Transit Authority – County Connection Headquarters – Bus Facility – EOC	2477 Arnold Industrial Way, Concord, CA 94520	N38 00.642 W122 01.499	Low
FERRY SYSTEMS			
San Francisco Bay Area Water Transit Authority Administration and EOC	Pier 9, Suite 111 The Embarcadero San Francisco, CA	N37° 48'09" W122° 23'45"	High
Alameda Harbor Bay Service	2 McCartney Road Alameda, CA, 94502	N37 44.277 W122 15.434 Or N37 44.276 W122 15.486	High
Alameda Oakland Ferry	Jack London Square 311 Broadway Oakland, CA	N37 47.667 W122 16.549 Or N37 47.638 W122 16.637	High
Angel Island/Tiburon Ferry	Main and Tiburon Boulevard Tiburon, CA	N37 52.411 W122 27.343 Or N37 52.369 W122 27.335	High
Golden Gate Ferry			
Larkspur Ferry Terminal	101 E. Sir Francis Drake Blvd. (at Larkspur Landing Cir.) Larkspur, CA 94904	N37 56.75227, W122 30.687 Or N37 56.602 W122 30.761	High
Sausalito Ferry Terminal – Loading Dock Only	Bridgeway and Caledonia Street (between Anchor and Napa Streets) or Humboldt and Anchor Streets Sausalito, CA 94965	N37 51.533 W122 28.959	High
Vallejo Baylink Ferry	289 Mare Island Way Vallejo, CA	N38 06.056 W122 15.761	High

Entity	Street Address	Coordinates	Probability
AIRPORTS			
San Francisco International		N37° 36'53.03" W122° 23'31.49"	Medium-High Runways impacted
Oakland International	1 Airport Drive Oakland, CA	N37° 43'09.90" W122° 12'31.59"	Medium-High Runways impacted
Norman Y. Mineta San Jose International Airport	1661 Airport Boulevard San Jose, CA	N37° 21'55.07" W121° 55'21.94"	Medium-High Runways impacted
PORTS			
Port of San Francisco			
Port of San Francisco – Administration - DOC	Pier 1 San Francisco, CA	N37° 47'50.89" W122° 23'38.65"	High
Ferry Building	Embarcadero at the end of Market Street San Francisco, CA	N37 47.735 W122 23.575	High
Pier 39		N37 48.529 W122 24.547	High
Pier 41	The Pier 41 Ferry Terminal, is located next to Pier 39	N37 48.560 W122 24.726	High
Port of San Francisco	Pier 9, 15 and 17 San Francisco, CA	N37° 48'09" W122° 23'.45"	High
Port of San Francisco	Pier 33, 35 and 45 San Francisco, CA	N37° 48'36" W122° 24'.20"	High
Port of San Francisco	Pier 30 and 32 San Francisco, CA	N37° 47'12" W122° 23'.00"	High
Port of San Francisco	Pier 50 and 54 San Francisco, CA	N37° 46'24" W122° 22'.50"	High
Port of San Francisco	Pier 70 and 80 San Francisco, CA	N37° 45'43" W122° 22'.47"	High
Port of San Francisco	Pier 90, 92 and 94-96 San Francisco, CA	N37° 44'50" W122° 22'.48"	High
Port of Oakland			
Port of Oakland - Administration	530 Water Street Oakland, CA	N37° 47'43.85" W122° 16'43.40"	Medium
Port of Oakland	Oakland Inner Harbor Oakland, CA	N37° 47'35.68" W122° 18'02.94"	Medium
Port of Oakland	Oakland Outer Harbor Oakland, CA	N37° 49'02" W122° 18'56"	Medium
Port of Redwood City	Wharves 1, 2, 3, 4 and Redwood City Wharf	N37° 30'42" W122° 12'40"	Medium
Port of Richmond			
City of Richmond	Terminals No. 1, 2, 4, 7 Wharfs Richmond, CA	N37° 57'50" W122° 25'41"	Low
City of Richmond Chevron	Long Pier Richmond, CA	N37° 55'25" W122° 24'40"	Low
City of Richmond	Container Terminal Pier 3 Wharf Richmond, CA	N37° 54'50" W122° 21'39"	Low
Port of Benicia	Valero-Benicia refinery and Benicia Industries Benicia, CA	N38° 02'41" W122° 07'45"	NA

Entity	Street Address	Coordinates	Probability
INTERCHANGES – STATE ROADWAYS			
Route 1	Marin County at milepost 50.5 - at Sonoma County line, Estero Americano Creek bridge	-	High
Route 1	Marin County at milepost 6.0 – 12.0 – from Muir Beach to Stinson Beach	-	High
Route 101	San Francisco City/County at milepost 9.4 – 9.8 - Doyle Drive Viaduct	N37° 48' 05.77" W122° 27' 19.75"	High
Route 1	San Mateo County at milepost 39.0 – 40.0 – Devil's Slide near Pacifica	N37° 33' 52.56" W122° 30' 45.27"	High
Route 84	San Mateo County at milepost 9.0 – 16.0 near la Honda	-	High
Route 280	San Mateo County at milepost 10.8 – 10.9 – near Belmont, Routes 92 / 280 interchange	N37° 30' 43.40" W122° 20' 48.29"	High
Route 1	Sonoma County at milepost 10.0 to 35.0 – from Jenner to Fort Bragg	-	High
OTHER FACILITIES			
Coastal Region Regional Emergency Operations Center	1300 Clay Street, Suite 400 Oakland, CA	N37° 48'16.26" W122° 16'26.14"	Medium
California Highway Patrol – Golden Gate Division EOC	1551 Benicia Drive Vallejo, CA	N38° 05'13.11" W122° 12'17.64"	Low
Alameda County Operational Area EOC	4985 Broder Boulevard Dublin, CA	N37° 42'57.92" W121° 53'24.71"	Low
Contra Costa Operational Area EOC	50 Glacier Drive Martinez, CA	N37° 59'23.31" W122° 05'14.67"	Low
Marin Operational Area EOC	3501 Civic Center Drive San Rafael, CA	N37° 59'50.88" W122° 31'45.26"	NA
San Francisco Operational Area EOC	1011 Turk Street San Francisco, CA	N37° 46'52.21" W122° 25'32.57"	Medium
San Mateo Operational Area EOC	400 County Center Redwood City, CA	N37° 29'18.14" W122° 13'48.46"	NA
Santa Clara Operational Area EOC	55 W. Younger Avenue, 4th Floor San Jose, CA	N37° 20'32.16" W121° 54'03.35"	NA

1.8. Effects – Liquefaction

Liquefaction occurs when seismic waves pass through saturated granular soil, distorting its granular structure, and causing some of the empty spaces between granules to collapse. Pore-water pressure may also increase sufficiently to cause the soil to behave like a fluid for a brief period and causing deformations. Liquefaction causes lateral spreads (horizontal movement commonly 10 to 15 feet, but up to 100 feet), flow failures (massive flows of soil, typically hundreds of feet, but up to several miles), and loss of bearing strength (soil deformations causing structures to settle or tip). There are many potential adverse consequences of liquefaction, including small building settlements, larger settlements associated with reduction of foundation bearing strength, and large lateral ground displacements that would tend to shear a building apart.

Figure A-8 shows a map of areas in the San Francisco Bay where the liquefaction is likely to occur based on a repeat of the 1906 San Andreas earthquake. Figure A-9 shows a map of liquefaction in the entire Bay Area, with green indicating liquefaction zones.

**Figure A-8
Liquefaction Zones**

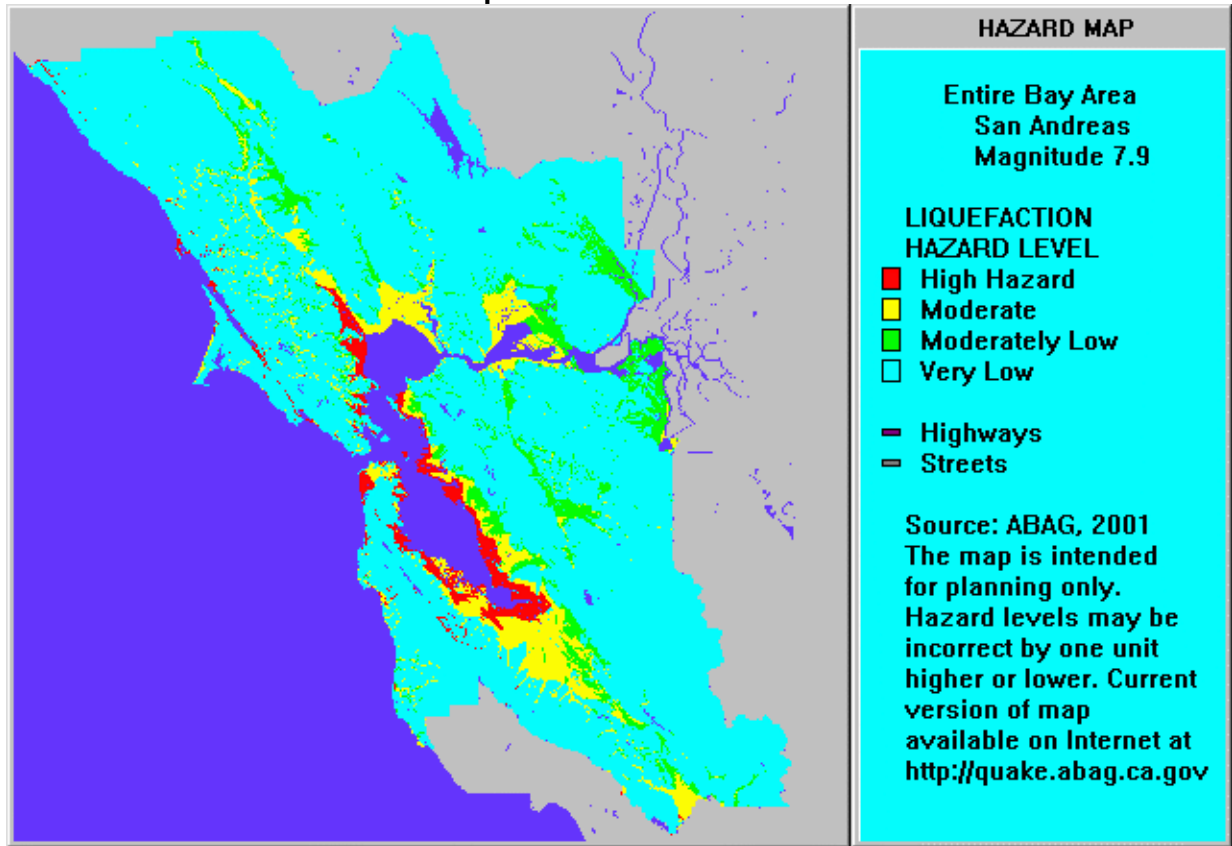
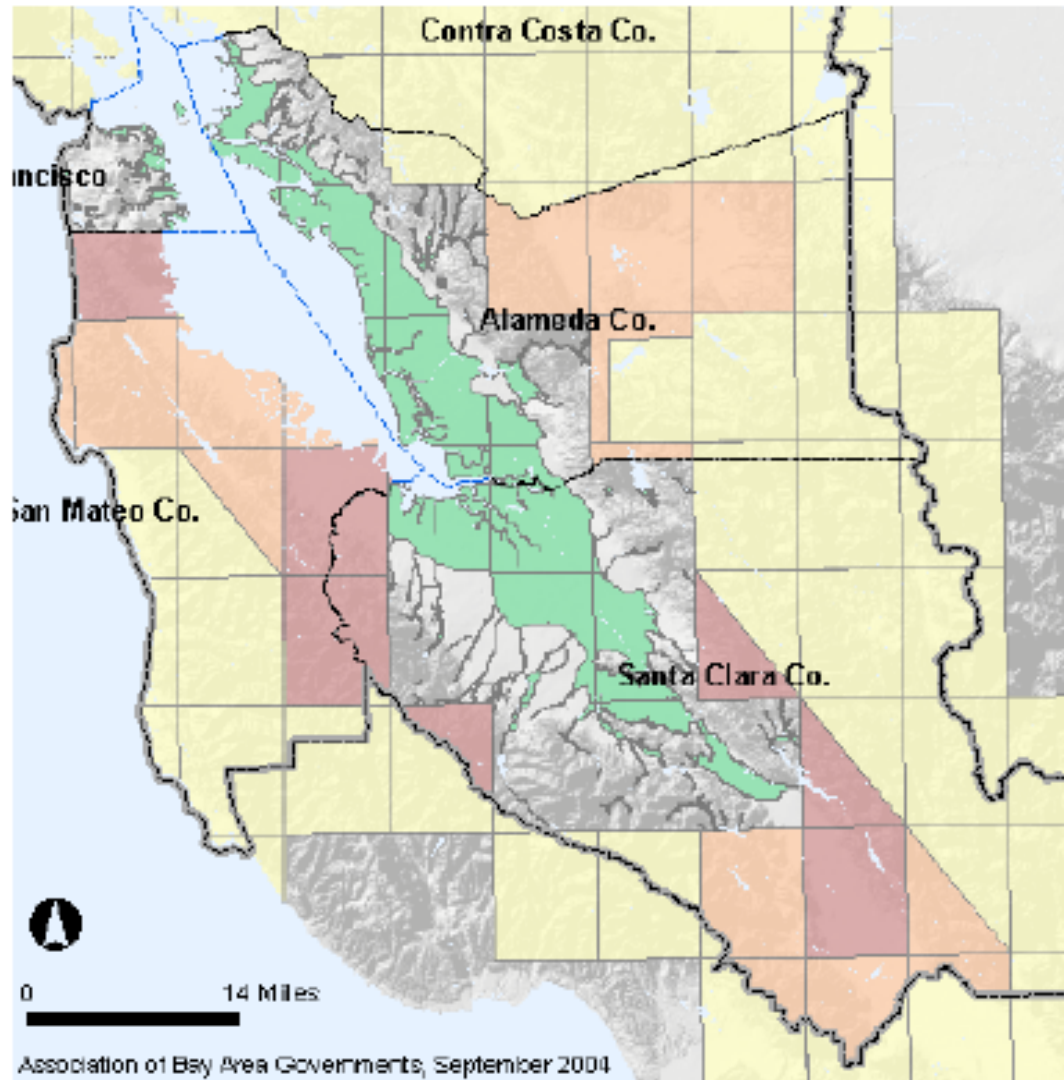
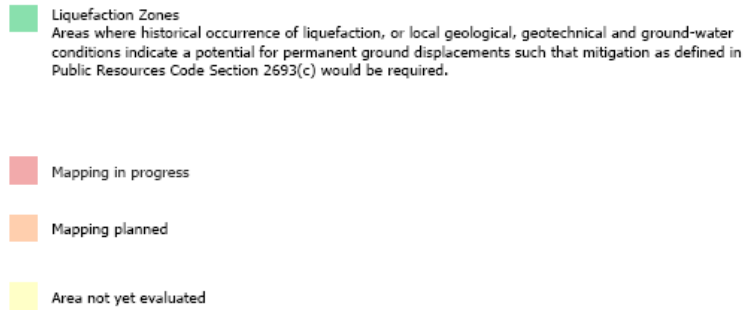


Figure A-9
Liquefaction in San Francisco Bay Area





1.9. Transit Facilities and a Repeat of the 1906 San Andreas Earthquake

The following are a series of maps depicting the location of transit facilities, the location of the San Andreas fault and the shaking in the Bay Area after an earthquake replicating the 1906 San Andreas earthquake.

The first map is an index, followed by smaller maps. The red color indicates the shaking after this earthquake and shows that a number of transit facilities are located either near the San Andreas fault or are located in areas that will feel the impact of ground level shaking.

After the maps is a listing of transit facilities in the Bay Area by address and coordinates. This information was used to identify the location of transit facilities for mapping purposes.

Figure A-10

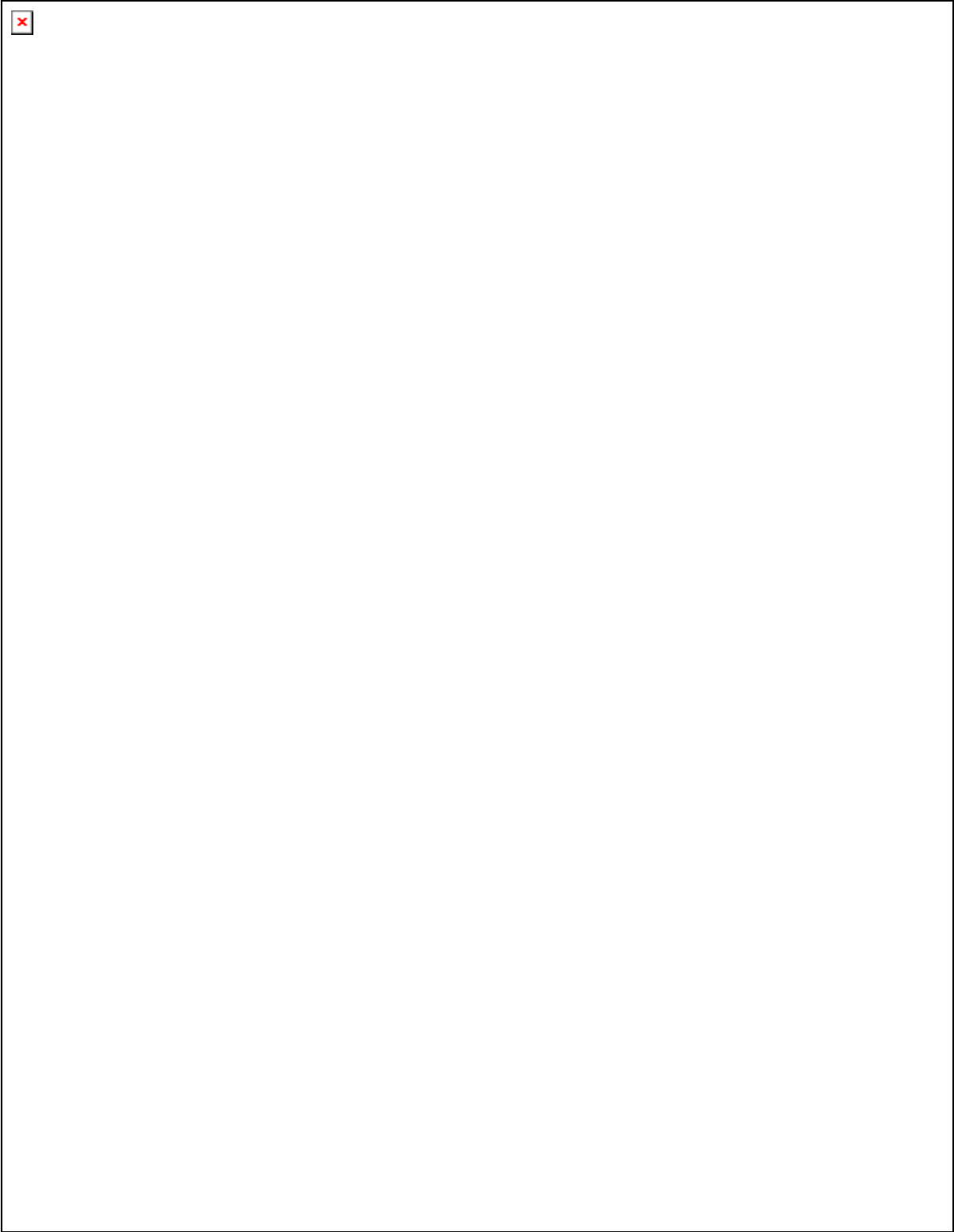


Figure A-11

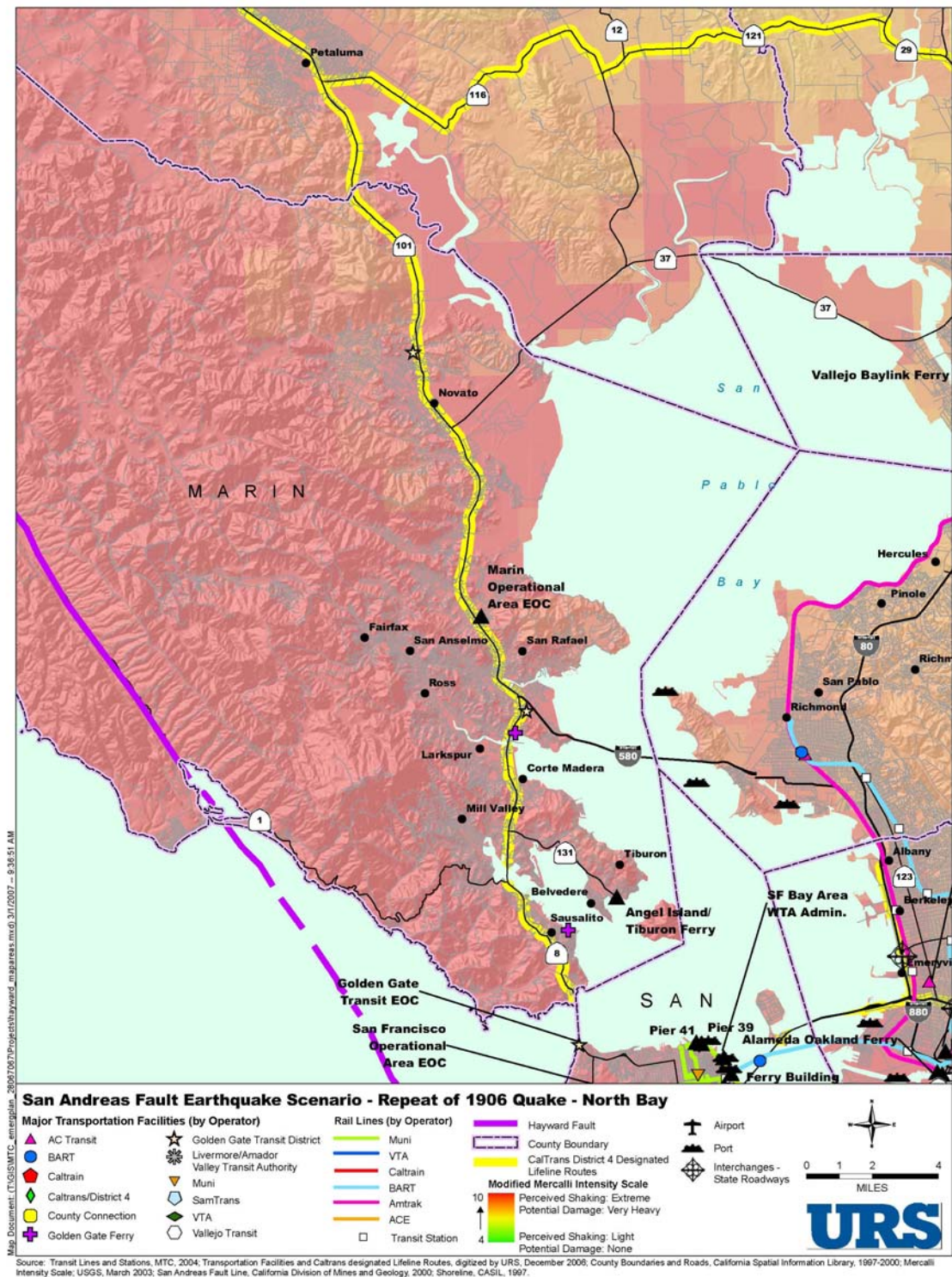


Figure A-12

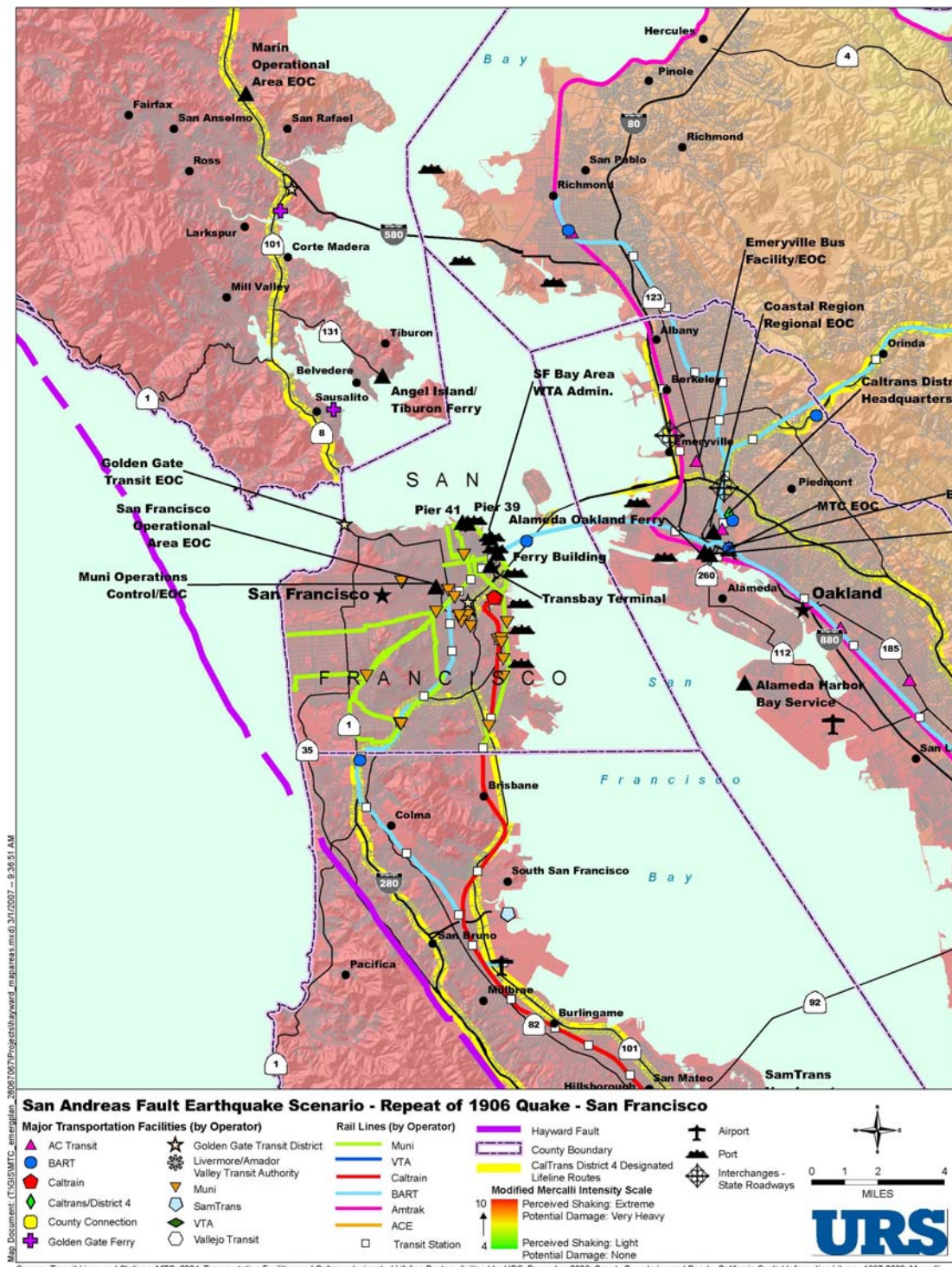


Figure A-14

